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PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : C22B 11/08, 11/00, 3/18

A1

(11) International Publication Number: **WO 97/14818**

(43) International Publication Date: 24 April 1997 (24.04.97)

(21) International Application Number: PCT/GB96/02538

(22) International Filing Date: 16 October 1996 (16.10.96)

(30) Priority Data:
95/8716 16 October 1995 (16.10.95) ZA

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(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published

With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: GOLD EXTRACTION PROCESS INCLUDING BIOFLOTATION

(57) Abstract

Process for extracting gold from mineral suspension includes at least one stage of flotation using the flotoreagents, following which the microorganism culture in an amount between 10.0 to 30.0 grams per ton is introduced into the flotation tails, and the agitation is performed during 6.0 to 10.0 minutes. The biomass of microorganism culture in an amount between 10.0 to 30.0 grams per ton is then additionally introduced into the mixture of the flotation tails and microorganism culture, and the flotation of said mixture is performed over a period between 12.0 to 15.0 minutes.

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GOLD EXTRACTION PROCESS INCLUDING BIOFLOTATION

The invention relates to a process for extracting gold from mineral suspension, in particular, from the tails containing the finely-dispersed gold, and can be used at the gold-extracting plants.

Different processes of enrichment of gold-containing ore are known to be used for extracting gold therefrom with the concentrate of the increased gold content being produced thereby. Flotation is known to be one of the widely used processes of gold-containing ore enrichment. Processing of the flotation concentrate in order to recover gold therefrom is simpler and cheaper than the similar treatment of total ore stock. Sometimes the flotation enrichment does not allow to extract all gold contained in concentrate. Nevertheless, even in this case the flotation is advisable, because this process permits to transform into the concentrate the most persistent part of gold which is not usually extracted by the conventional techniques of gravitation enrichment, cyanidation and amalgamation.

Schemes and conditions of the flotation enrichment process depend on ore quality and are known to be of a wide variety. There are, however, the general features specific for all schemes of gold-containing ore flotation. So, the processing of almost all kinds of ore involves the stage flotation (most frequently, it is a two-stage process).

Various flotoreagents or flotation reagents, in particular, collectors, foaming agents, foam stabilizers, etc. are usually used in the process of flotation. Sulphide-hydril reagents, namely, butyl-, amilethyl-xantogenates are used as collectors. Xantogenates are usually selectively adsorbed, that is, they are fixed upon the most active areas of gold surface with hydrophobization of gold surface being provided, and the flotation process being improved thereby. Soya oil is usually used as a foaming agent. A little of fatty-acid reagent, such as sodium oleate is added to stabilize the foam. Suppression of empty rock is achieved by means of liquid glass,

carboxymethylcellulose and other reagents.

Such reagents as cyanides, sodium sulphide, alkali, blue vitriol, sodium sulphate are are often present in the flotation pulp. To greater or lesser extent these reagents supress the gold flotation process. The strongest supressor is sodium sulphide. The floatibility of gold is also decreased with the increase in pH value of the suspension. The floatability of free gold in acid medium is lower than in the neutral one, that results from the decrease of xantogenase adsorption upon the gold surface and from the reduction in pH value of the solution. The flotation of gold and gold-containing sulphides is actually performed at pH between 7.5 to 8.5 with soda being used as pH value regulator.

Upon completion of the flotation process the flotation tails still contain gold, mainly the finely-disperse one, which is further extracted by cyanidation technique (L.V. Chuguyev. Metallurgy of noble metals. Moscow, " Metallurgy". 1987, p. 269-270).

So, as follows from the above , the use of stage flotation for extracting gold from gold-containing ore to be present in the form of mineral suspension makes possible to recover gold from the most persistent ores, which is not achieved by other known techniques of ore enrichment.

The flotation tails, however, still contain a considerable amount of gold, basically the finely-disperse one. Further extraction of gold from the flotation tails is performed by the cyanidation technique which is environmentally harmful.

The problem of the invention is to develop a process for extracting gold from the mineral suspension, wherein reagents, techniques and parameters of performing thereof enable to provide the conditions under which the maximum extraction of gold from the flotation tails is being achieved, and the environment is not harmfully affected.

The problem is solved by that in the known process for extracting gold from mineral

suspension consisting in that at least one stage of flotation is performed using the known flotoreagents, according to the invention after at least one stage of flotation the biomass of microorganism culture in an amount between 10.0 to 30.0 grams per ton is introduced into the flotation tails, and the agitation is performed over a period between 6.0 to 10.0 minutes after which the biomass of microorganism culture in an amount between 10.0 to 30.0 grams per ton is further added to the mixture of the flotation tails and microorganism culture, and the flotation of said mixture is performed over a period between 12.0 to 15.0 minutes.

Said process allows to increase the extraction of finely-disperse gold to be present in the flotation tails with the environmentally harmful reagents being not involved in the process. This effect is achieved because in the process of agitation of a mixture of flotation tails and microorganism culture under said parameters there are created the most favorable conditions for the interaction between the microorganism culture and the surface of ore particles containing the finely-disperse gold with the bioaggregates of a size between 0. 060 to 0.070 mm being produced thereby. This provides the improved extraction of gold as well as of other noble metals. such as silver from the flotation tails in the process of further flotation thereof.

It is advisable that the electric field of intensity 0.5-2.0 V/cm be produced 0.5 - 1.0 minute prior to the completion of agitation, and the process of agitation be performed under effect of this electric field.

Under the effect of electric field to be applied prior to the completion of agitation of the flotation tails and microorganism culture the process of interaction of microorganism culture and gold particles is intensified due to the effect of polarization.

It is recommended that after the flotation of a mixture of the flotation tails and microorganism culture during between 2.0 to 3.0 minutes the electric field of intensity

between 1.5 to 2.5 V/cm be produced, and the flotation be performed under the effect of the electric field over a period between 1.0 to 1.5 minutes with further flotation being carried without the action of said electric field.

Said modification of the process provides the preservation of the produced bioaggregates at the moment of dispersing action of the floating mashine impeller.

It is the most rational that 0.5 - 1.0 minute prior to the completion of agitation the electric field of the intensity between 0.5 to 2.0 V/cm be produced, and the process of agitation be performed under the effect of electric field. and after the flotation of a mixture of the flotation tails and microorganism culture during between 2.0 to 3.0 minutes the electric field of intensity between 1.5 to 2.5 V/cm be induced, and the flotation of said mixture be carried out over a period between 1.0 to 1.5 minutes under the effect of electric field, then the electric field be switched off, and the flotation be continued without the action of said electric field.

Said modification of the process provides the most favorable conditions for producing bioaggregates in the process of agitation and for performing the flotation of said bioaggregates.

It is preferable that the **Bacillus cereus B - 5039** be used as a microrganism culture.

Said microorganism culture is characterized by the highest degree of selectivity towards the gold, which increases the number of produced bioaggregates resulting in the growth of gold extraction rate.

The process for extracting gold from mineral suspension according to the invention is practised as below described.

Ore gravitation tails used as a starting raw material and containing 4.6 grams per ton of gold and 9.0 grams per ton of silver were utilized for performing the process. The

gravitation tails were disintegrated on the conventional grinding machine with 60% of ore being of a particle size 0.074 mm. The mineral suspension was further prepared by mixing the disintegrated ore and water at a ratio of solid phase to the liquid one being 1:5. Said mineral suspension was subjected to the flotation on the conventional floating machine of the lab or large-scale type. The volume of the lab floating machine chamber was 1.5 litre. The flotation process, hereafter referred to as a basic flotation, was performed in the presence of the commercially applied flotoreagents such as butyl potassium xantogenate used in an amount 60.0 grams per ton and pine oil in an amount 80.0 grams per ton. The flotation was performed during 20.0 minutes. The tails of basic flotation representing the mineral suspension were supplied from the flotation chamber to the intermediate vessel of a volume between 2.0 to 3.0 litres which is provided with an agitation device and the electrodes to be connected to the direct power supply source. The biomass of microorganism culture in an amount between 10.0 to 30.0 grams per ton was introduced into this vessel, and the agitation of a mixture of the basic flotation tails and microorganism culture was performed during a period between 6.0 to 10.0 minutes.

As a microorganism culture there could be used any microorganism culture capable of coagulating gold, e.g. the green algae of Chlorella kind. The most rational is to use the microorganism culture of **Bacillus cereus** kind, strain 5039, deposited in the All-Union Collection of Industrial Microorganisms of VNIT Genetics Institute on 24 October, 1989 under Deposit No. B5039.

The culture-morphological and physico-biochemical features of the **Bacillus cereus** VKPM 5039 strain are as below described.

The bacteria are bacillus-like of a cell length between 3.0 to 5.0mm and of a cell width between 1.0 to 1.2 mm. They are gram-positive, produce the ellipse-like spores and are of central location. On the meat-peptone agar they form a solid film, and produce little turbidity and deposit. When being grown upon the meat-peptone broth the bacteria do not produce

hydrogen sulphide, indol and ammonia. Hydrolize starch, do not hydrolize kasein, urea and thyrazine. Do not produce acids from mannite, sorbitol, xylose, arabinose. An acid is formed from glucose and sacharose. Produce catalaze. The Foges-Proskauer reaction is positive. Reduce nitrates into nitrites, do not form a gas from glucose. The bacteria do not grow in the presence of 7.0% NaCl.

The optimal temperature of cultivation is 30°C. the maximum one reaches 40.0°C. The minimum temperature is 10.0°C.

Said microorganism strain was separated from the shelves of the Far East. It is characterized by the increased capacity to gold coagulation. Said microorganism culture is cultivated on the meat-peptone broth (1:3) or in 3-5% solution of the hydralizate of carbohydrate-oxidating yeast prepared on oil paraphines at a temperature between 30.0°to 32.0°C and pH between 6.3 to 6.7.

The agitation of the flotation tails and microorganism culture was performed over a period between 6.0 to 10.0 minutes in the presence of sodium hexametaphosphate which is also introduced into said vessel. 0.5 - 1.0 minute prior to the completion of agitation the power supply source could be connected to the electrodes, and the agitation of said mixture be performed under effect of the electric field of the intensity between 0.5 to 2.0 V/cm. The mixture of the flotation tails and biomass of microorganism culture was further supplied to the floating mashine with its chamber being provided with the electrodes connected to the direct power supply source. The biomass of microorganism culture in an amount between 10.0 to 30.0 grams per ton as well as such flotoreagents as buthyl potassium xantogenate in an amount between 40.0 to 60.0 grams per ton and pine oil in an amount between 40. 0 to 45.0 grams per ton were introduced into the chamber of said floating mashine. The flotation process which is further referred to as a bioflotation process was performed over a period

between 12.0 to 15.0 minutes. 2.0 - 3.0 minutes after starting the bioflotation process the direct power supply source may be switched on, and bioflotation be carried out during between 1.0 to 1.5 minute under the effect of electric field of intensity between 1.5 to 2.5 V/cm.

Following this procedure the power supply source was disconnected, and the bioflotation was further performed without the electric field being applied.

Upon completion of bioflotation the concentrates of the basic flotation and bioflotation processes as well as the bioflotation tails were dried.

The yield, the gold and silver content in said concentrates and flotation tails were determined.

Here it is presented the laboratory embodiment of performing the process according to the invention.

It is, however, obvious that said technology may be realized under large scale conditions using the widely applied floating mashines.

The examples of practising the invention are presented below.

Example 1

Process for extracting gold from mineral suspension according to the invention was practised as below described.

Pre-desintegrated tails of gravitation ore enrichment in an amount 250.0 grams were used to perform the process. 60% of mineral particles were of a size 0.074 mm. The mineral suspension was prepared with the ratio of solid particles to liquid being 1:5.

The basic flotation was performed in the impeller-type floating mashine of a chamber volume 1.5 litre. The flotation was performed over a period of 20 minutes in the presence of buthyl potassium xantogenate in an amount 60.0 grams per ton, and of pine oil in an amount 80.0 grams per ton.

From the floating mashine the mineral suspension was further supplied to an intermediate agitation vessel of a volume 2.0 litres provided with the electrodes connected to direct power supply source and designed for inducing an electric field. The biomass of microorganism culture Bacillus cereus VKPM 5039 in an amount 25 grams per ton and sodium hexametaphosphate in an amount 40 grams per ton were introduced into this vessel, and the mixture of mineral suspension and microorganism culture was subjected to agitation over a period of 6.0 minutes. 0.75 minutes prior to the completion of agitation the direct power supply source was switched on, the electric field of intensity 0.5 V/cm was produced in said vessel, and the agitation of said mixture was performed under the effect of electric field.

Upon completion of agitation the mixture of mineral suspension and microorganism culture was supplied to the floating mashine provided with electrodes connected to the direct power supply source. 15.0 grams per ton of said microorganism culture, 45 grams per ton of buthyl potassium xantogenate and 45.0 grams per ton of pine oil were additionally

introduced into the floating mashine, and bioflotation was performed during 2.0 minutes.

The direct power supply source was then switched on, the electric field of intensity 2.5 V/cm was produced in the floating mashine cell, and bioflotation was performed under the effect of electric field during 1.5 minutes. The power supply source was then switched off, and bioflotation was further performed without the action of electric field. The total duration of bioflotation process constituted 14.0 minutes.

Having completed the flotation, the concentrates of basic flotation and bioflotation processes as well as the flotation tails were dried, the yield, the gold and silver content were determined therein.

The obtained results are summarized in Table 1.

Example 2

Process for extracting gold from mineral suspension according to the invention was realized as hereafter described.

The tails of gravitation ore enrichment in an amount 250.0 grams were used for performing the process. The preliminary operations were carried out as in example 1. The basic flotation was performed as described in example 1. After the basic flotation the mineral suspension was supplied from the floating mashine cell to the intermediate vessel similar to that described in example 1, whereinto the biomass of microorganism culture **Bacillus cereus** VKPM 5039 in an amount 10.0 g/t and 40.0 g/t of sodium hexametaphosphate were introduced, and the agitation of the obtained mixture was performed during 6.0 minutes. 0.5 minutes prior to completion of agitation the electric field of intensity 0.5 V/cm was produced in said agitation vessel, and agitation was performed under the effect of the electric field. Upon completion of agitation said mixture was supplied to the floating mashine similar to that described in example 1 to realize the bioflotation process. 20.0 g/t of biomass of said microorganism culture, 45.0 g/t of buthyl potassium xantogenate, 45.0 g/t of pine oil were additionally introduced into the floating mashine cell, and bioflotation was performed during 2.0 minutes. The electric field of intensity 2.0 V/cm was then induced in the bioflotation cell and bioflotation was carried out over a period of 1.0 minute under the effect of electric field.

Total duration of bioflotation process was 12.0 minutes.

The yield, the gold and silver content were determined in the concentrates of basic flotation and bioflotation processes as well as in the bioflotation tails.

The results are given in Table 1.

Example 3

Process for extracting gold from mineral suspension according to the invention was realized as hereafter described.

The tails of gravitation ore enrichment in an amount 250.0 grams were used for performing the process. The preliminary operations were carried out as in example 1. The basic flotation was performed as described in example 1. After the basic flotation the mineral suspension was supplied from the floating mashine cell to the intermediate vessel similar to that described in example 1, whereinto the biomass of microorganism culture **Bacillus cereus** VKPM 5039 in an amount 10.0 g/t and 40.0 g/t of sodium hexametaphosphate were introduced, and the agitation of the obtained mixture was performed during 6.0 minutes. 1.0 minute prior to completion of agitation the electric field of intensity 2.0 V/cm was produced in said agitation vessel, and agitation was performed under the effect of electric field. Upon completion of agitation said mixture was supplied to the floating mashine similar to that described in example 1 to realize the bioflotation process. 30.0 g/t of biomass of said microorganism culture, 40.0 g/t of buthyl potassium xantogenate, 40.0 g/t of pine oil were additionally introduced into the floating mashine cell, and bioflotation was performed during 2.0 minutes. The electric field of intensity 2.5 V/cm was then induced in the bioflotation cell and bioflotation was carried out over a period of 1.5 minute under the effect of electric field.

Total duration of bioflotation process was 12.0 minutes.

The yield, the gold and silver content were determined in the concentrates of basic flotation and bioflotation processes as well as in the bioflotation tails.

The results are given in Table 1.

Example 4

Process for extracting gold from mineral suspension according to the invention was realized as hereafter described.

The tails of gravitation ore enrichment in an amount 250.0 grams were used for performing the process. The preliminary operations were carried out as in example 1. The basic flotation was performed as described in example 1. After the basic flotation the mineral suspension was supplied from the floating mashine cell to the intermediate vessel similar to that described in example 1, whereinto the biomass of microorganism culture **Bacillus cereus** VKPM 5039 in an amount 10.0 g/t and 40.0 g/t of sodium hexametaphosphate were introduced, and the agitation of the obtained mixture was performed during 10.0 minutes. 0.5 minute prior to completion of agitation the electric field of intensity 2.0 V/cm was produced in said agitation vessel, and agitation was performed under the effect of electric field. Upon completion of agitation said mixture was supplied to the floating mashine similar to that described in example 1 to realize the bioflotation process. 30.0 g/t of biomass of said microorganism culture, 60.0 g/t of buthyl potassium xantogenate, 40.0 g/t of pine oil were additionally introduced into the floating mashine cell, and bioflotation was performed during 2.0 minutes. The electric field of intensity 1.5 V/cm was then induced in the bioflotation cell and bioflotation was carried out over a period of 1.0 minute under the effect of electric field.

Total duration of bioflotation process was 12.0 minutes.

The yield, the gold and silver content were determined in the concentrates of basic flotation and bioflotation processes as well as in the bioflotation tails.

The results are given in Table 1.

Example 5

Process for extracting gold from mineral suspension according to the invention was realized as hereafter described.

The tails of gravitation ore enrichment in an amount 250.0 grams were used for performing the process. The preliminary operations were carried out as in example 1. The basic flotation was performed as described in example 1. After the basic flotation the mineral suspension was supplied from the floating mashine cell to the intermediate vessel similar to that described in example 1, whereinto the biomass of microorganism culture **Bacillus** cereus VKPM 5039 in an amount 15.0 g/t and 40.0 g/t of sodium hexametaphosphate were introduced, and the agitation of the obtained mixture was performed during 6.0 minutes. 0.5 minute prior to completion of agitation the electric field of intensity 1.5 V/cm was produced in said agitation vessel, and agitation was performed under the effect of electric field. Upon completion of agitation said mixture was supplied to the floating mashine similar to that described in example 1 to realize the bioflotation process. 20.0 g/t of biomass of said microorganism culture, 50.0 g/t of buthyl potassium xantogenate, 40.0 g/t of pine oil were additionally introduced into the floating mashine cell, and bioflotation was performed during 2.0 minutes. The electric field of intensity 1.5 V/cm was then induced in the bioflotation cell and bioflotation was carried out over a period of 1.0 minute under the effect of electric field.

Total duration of bioflotation process was 15.0 minutes.

The yield, the gold and silver content were determined in the concentrates of basic flotation and bioflotation processes as well as in the bioflotation tails.

The results are given in Table 1.

Example 6

Process for extracting gold from mineral suspension according to the invention was realized as hereafter described.

The tails of gravitation ore enrichment in an amount 250.0 grams were used for performing the process. The preliminary operations were carried out as in example 1. The basic flotation was performed as described in example 1. After the basic flotation the mineral suspension was supplied from the floating mashine cell to the intermediate vessel similar to that described in example 1, whereinto the biomass of microorganism culture **Bacillus cereus** VKPM **5039** in an amount 30.0 g/t and 40.0 g/t of sodium hexametaphosphate were introduced, and the agitation of the obtained mixture was performed during 6.0 minutes. 0.5 minute prior to completion of agitation the electric field of intensity 0.5 V/cm was produced in said agitation vessel, and agitation was performed under the effect of electric field. Upon completion of agitation said mixture was supplied to the floating mashine similar to that described in example 1 to realize the bioflotation process. 30.0 g/t of biomass of said microorganism culture, 60.0 g/t of buthyl potassium xantogenate, 40.0 g/t of pine oil were additionally introduced into the floating mashine cell, and bioflotation was performed during 3.0 minutes. The electric field of intensity 2.5 V/cm was then induced in the bioflotation cell and bioflotation was carried out over a period of 1.5 minute under the effect of electric field.

Total duration of bioflotation process was 13.0 minutes.

The yield, the gold and silver content were determined in the concentrates of basic flotation and bioflotation processes as well as in the bioflotation tails.

The results are given in Table 1.

Example 7

Process for extracting gold from mineral suspension according to the invention was realized as hereafter described.

The tails of gravitation ore enrichment in an amount 250.0 grams were used for performing the process. The preliminary operations were carried out as in example 1. The basic flotation was performed as described in example 1. After the basic flotation the mineral suspension was supplied from the floating mashine cell to the intermediate vessel similar to that described in example 1, whereinto the biomass of microorganism culture **Bacillus cereus** VKPM 5039 in an amount 10.0 g/t and 40.0 g/t of sodium hexametaphosphate were introduced, and the agitation of the obtained mixture was performed during 6.0 minutes. 0.5 minute prior to completion of agitation the electric field of intensity 0.5 V/cm was produced in said agitation vessel, and agitation was performed under the effect of electric field. Upon completion of agitation said mixture was supplied to the floating mashine similar to that described in example 1 to realize the bioflotation process. 25.0 g/t of biomass of said microorganism culture, 45.0 g/t of butkyl potassium xantogenate and 45.0 g/t of pine oil were additionally introduced into the floating mashine cell, and bioflotation was performed during 2.0 minutes. The electric field of intensity 2.5 V/cm was then induced in the bioflotation cell and bioflotation was carried out over a period of 1.5 minute under the effect of electric field.

Total duration of bioflotation process was 14.0 minutes.

The yield, the gold and silver content were determined in the concentrates of basic flotation and bioflotation processes as well as in the bioflotation tails.

The results are given in Table 1.

Example 8

Process for extracting gold from mineral suspension according to the invention was realized as hereafter described.

The tails of gravitation ore enrichment in an amount 250.0 grams were used for performing the process. The preliminary operations were carried out as in example 1. The basic flotation was performed as described in example 1. After the basic flotation the mineral suspension was supplied from the floating mashine cell to the intermediate vessel similar to that described in example 1, whereinto the biomass of microalga culture **Chlorella Vulgaris Larg** 3. in an amount 30.0 g/t and 40.0 g/t of sodium hexametaphosphate were introduced, and the agitation of the obtained mixture was performed during 6.0 minutes. 0.75 minute prior to completion of agitation the electric field of intensity 0.5 V/cm was produced in said agitation vessel, and agitation was performed under the effect of electric field. Upon completion of agitation said mixture was supplied to the floating mashine similar to that described in example 1 to realize the bioflotation process. 10.0 g/t of biomass of said microalga culture, 50.0 g/t of buthyl potassium xantogenate and 45.0 g/t of pine oil were additionally introduced into the floating mashine cell, and bioflotation was performed during 2.0 minutes. The electric field of intensity 2.0 V/cm was then induced in the bioflotation cell and bioflotation was carried out over a period of 1.0 minute under the effect of electric field.

Total duration of bioflotation process was 12.0 minutes.

The yield, the gold and silver content were determined in the concentrates of basic flotation and bioflotation processes as well as in the bioflotation tails.

The results are given in Table 1.

Example 9

Process for extracting gold from mineral suspension according to the invention was realized as hereafter described.

The tails of gravitation ore enrichment in an amount 250.0 grams were used for performing the process. The preliminary operations were carried out as in example 1. The basic flotation was performed as described in example 1. After the basic flotation the mineral suspension was supplied from the floating mashine cell to the intermediate vessel similar to that described in example 1, whereinto the biomass of microorganism culture **Bacillus cereus** VKPM 5039 in an amount 25.0 g/t and 40.0 g/t of sodium hexametaphosphate were introduced, and the agitation of the obtained mixture was performed during 6.0 minutes. Upon completion of agitation said mixture was supplied to the floating mashine similar to that described in example 1 to realize the bioflotation process. 20.0 g/t of biomass of said microorganism culture, 40.0 g/t of buthyl potassium xantogenate and 40.0 g/t of pine oil were additionally introduced into the floating mashine cell, and bioflotation was performed during 2.0 minutes.The electric field of intensity 1.5.0 V/cm was then induced in the bioflotation cell and bioflotation was carried out over a period of 1.0 minute under the effect of electric field.

Total duration of bioflotation process was 12.0 minutes.

The yield, the gold and silver content were determined in the concentrates of basic flotation and bioflotation processes as well as in the bioflotation tails.

The results are given in Table 1.

Example 10

Process for extracting gold from mineral suspension according to the invention was realized as hereafter described.

The tails of gravitation ore enrichment in an amount 250.0 grams were used for performing the process. The preliminary operations were carried out as in example 1. The basic flotation was performed as described in example 1. After the basic flotation the mineral suspension was supplied from the floating mashine cell to the intermediate vessel similar to that described in example 1, whereinto the biomass of microorganism culture **Bacillus cereus** VKPM **5039** in an amount 20.0 g/t and 40.0 g/t of sodium hexametaphosphate were introduced, and the agitation of the obtained mixture was performed during 6.0 minutes. 0.5 minutes prior to completion of agitation the electric field of intensity 1.5 V/cm was produced in said agitation chamber, and the agitation was carried out under the effect of electric field. Upon completion of agitation said mixture was supplied to the floating mashine similar to that described in example 1 to realize the bioflotation process. 20.0 g/t of biomass of said microorganism culture, 40.0 g/t of buthyl potassium xantogenate and 40.0 g/t of pine oil were additionally introduced into the floating mashine cell, and bioflotation was performed during 12.0 minutes.

The yield, the gold and silver content were determined in the concentrates of basic flotation and bioflotation processes as well as in the bioflotation tails.

The results are given in Table 1.

Example 11

Process for extracting gold from mineral suspension according to the invention was practised as below described.

The tails of gravitation ore enrichment in an amount 250.0 grams were used to perform the process.

The preliminary operations were performed as described in example 1.

The basic flotation was carried out as in example 1.

After the basic flotation the mineral suspension was further supplied from the floating machine chamber to the intermediate vessel similar to that of example 1, whereinto the biomass of microorganism culture Bacillus cereus VKPM 5039 in an amount 25.0 grams per ton and sodium hexametaphosphate in an amount 40.0 grams per ton were introduced, and the obtained mixture was subjected to agitation over a period of 6.0 minutes. After the completion of agitation the above mixture was supplied into the floating mashine as described in example 1.

20 grams per ton of the biomass of said microorganism culture, 40.0 grams per ton of buthyl potassium xantogenate and 40.0 grams per ton of pine oil were additionally introduced into the flotation chamber , and the bioflotation was performed during a period 12.0 minutes.

The yield, the gold and silver content were determined in the concentrates of basic flotation and bioflotation processes as well as in the bioflotation tails.

The obtained results are summarized in Table 1.

Example 12 (comparative)

Process for extracting gold from mineral suspension according to the invention was realized as hereafter described.

The tails of gravitation ore enrichment in an amount 250.0 grams were used for performing the process. The preliminary operations were carried out as in example 1. The basic flotation was performed as described in example 1. After the basic flotation the mineral suspension was supplied from the floating mashine cell to the intermediate vessel similar to that described in example 1, whereinto the biomass of microorganism culture **Bacillus cereus** VKPM 5039 in an amount 5.0 g/t and 40.0 g/t of sodium hexametaphosphate were introduced, and the agitation of the obtained mixture was performed during 6.5 minutes.0,25 minute prior to completion of agitation the electric field of intensity 1.5 V/cm was produced in said agitation chamber, and the agitation was carried out under the effect of electric field. Upon completion of agitation said mixture was supplied to the floating mashine similar to that described in example 1 to realize the bioflotation process. 5.0 g/t of biomass of said microorganism culture, 30.0 g/t of buthyl potassium xantogenate and 25.0 g/t of pine oil were additionally introduced into the floating mashine cell, and bioflotation was performed during 2.0 minutes.

The electric field of intensity 0.5 V/cm was then produced and the bioflotation process was performed during 1.5 minutes under the effect of electric field.

Total duration of bioflotation was 15 minutes.

The yield, the gold and silver content were determined in the concentrates of basic flotation and bioflotation processes as well as in the bioflotation tails.

The results are given in Table 1.

Example 13 (comparative)

Process for extracting gold from mineral suspension according to the invention was realized as hereafter described.

The tails of gravitation ore enrichment in an amount 250.0 grams were used for performing the process. The preliminary operations were carried out as in example 1. The basic flotation was performed as described in example 1. After the basic flotation the mineral suspension was supplied from the floating mashine cell to the intermediate vessel similar to that described in example 1, whereinto the biomass of microorganism culture Bacillus cereus VKPM 5039 in an amount 20.0 g/t and 40.0 g/t of sodium hexametaphosphate were introduced, and the agitation of the obtained mixture was performed during 7.0 minutes. 2.0 minute prior to completion of agitation the electric field of intensity 3.5 V/cm was produced in said agitation chamber, and the agitation was carried out under the effect of electric field. Upon completion of agitation said mixture was supplied to the floating mashine similar to that described in example 1 to realize the bioflotation process. 10.0 g/t of biomass of said microorganism culture, 30.0 g/t of buthyl potassium xanthogenate and 80.0 g/t of pine oil were additionally introduced into the floating mashine cell, and bioflotation was performed during 2.0 minutes.

The electric field of intensity 3.0 V/cm was then produced and the bioflotation process was performed during 1.6 minute (100 sec.) under the effect of electric field.

Total duration of bioflotation was 15 minutes.

The yield, the gold and silver content were determined in the concentrates of basic flotation and bioflotation processes as well as in the bioflotation tails.

The results are given in Table 1.

Example 14 (comparative)

Process for extracting gold from mineral suspension according to the invention was realized as hereafter described.

The tails of gravitation ore enrichment in an amount 250.0 grams were used for performing the process. The preliminary operations were carried out as in example 1. The basic flotation was performed as described in example 1. After the basic flotation the mineral suspension was supplied from the floating mashine cell to the intermediate vessel similar to that described in example 1, whereinto the biomass of microorganism culture **Bacillus cereus** VKPM 5039 in an amount 25.0 g/t and 40.0 g/t of sodium hexametaphosphate were introduced, and the agitation of the obtained mixture was performed during 6.0 minutes. 1.5 minute prior to completion of agitation the electric field of intensity 2.0 V/cm was produced in said agitation chamber, and the agitation was carried out under the effect of electric field. Upon completion of agitation said mixture was supplied to the floating mashine similar to that described in example 1 to realize the bioflotation process. 15.0 g/t of biomass of said microorganism culture, 80.0 g/t of buthyl potassium xantogenate and 80.0 g/t of pine oil were additionally introduced into the floating mashine cell, and bioflotation was performed during 2.0 minutes.

The electric field of intensity 2.0 V/cm was then produced and the bioflotation process was performed during 3.0 minutes under the effect of electric field.

Total duration of bioflotation was 14 minutes.

The yield, the gold and silver content were determined in the concentrates of basic flotation and bioflotation processes as well as in the bioflotation tails.

The results are given in Table 1.

Example 15 (comparative)

Process for extracting gold from mineral suspension according to the invention was realized as hereafter described.

The tails of gravitation ore enrichment in an amount 250.0 grams were used for performing the process. The preliminary operations were carried out as in example 1. The basic flotation was performed as described in example 1. After the basic flotation the mineral suspension was supplied from the floating mashine cell to the intermediate vessel similar to that described in example 1, whereinto 40.0 g/t of sodium hexametaphosphate was introduced, and the agitation of the obtained mixture was performed during 6.0 minutes. 0.5 minute prior to completion of agitation the electric field of intensity 2.0 V/cm was produced in said agitation chamber, and the agitation was carried out under the effect of electric field. Upon completion of agitation said mixture was supplied to the floating mashine similar to that described in example 1 to realize the bioflotation process. 40.0 g/t of buthyl potassium xantogenate and 40.0 g/t of pine oil were additionally introduced into the floating mashine cell, and flotation was performed during 2.0 minutes.

The electric field of intensity 1.5 V/cm was then produced intheflotation cell, and the flotation process was performed during 1.0 minute under the effect of electric field.

Total duration of flotation was 12.0 minutes.

The yield, the gold and silver content were determined in the concentrates of basic flotation and bioflotation processes as well as in the bioflotation tails.

The results are given in Table 1.

Table 1

Examples	Yield, %	Content, g/ton		Extraction, %	
		Au	Ag	Au	Ag
According to the invention					
1					
Concentrate of basic flotation	4.3	41.6	64.1	62.1	63.1
Concentrate of bio flotation	3.6	21.9	26.9	31.8	32.4
				93.9	
Tails	92.1	0.21	2.85	6.1	4.5
Initial raw material	100.0	4.6	9.0	100.0	100.0
2					
Concentrate of basic flotation	4.9	36.2	54.7	54.8	60.8
Concentrate of bioflotation	8.3	18.4	32.1	36.0	31.4
				90.8	
Tails	86.8	0.31	3.12	9.2	7.8
Initial raw material	100.0	4.6	9.0	100.0	100.0
3					
Concentrate of basic flotation	5.6	30.4	44.1	52.7	60.3
Concentrate of bioflotation	9.1	21.9	40.5	33.6	27.1
				96.3	
Tails	85.3	0.37	4.6	13.7	87.4
Initial raw material	100.0	4.6	9.0	100.0	100.0
4					
Concentrate of basic flotation	4.3	60.1	70.0	63.7	59.7
Concentrate of bioflotation	3.7	20.4	21.6	31.8	35.1
				95.5	
Tails	92.0	0.19	2.1	14.5	5.2

Initial raw material	100.0	4.6	9.0	100.0	100.0
5					
Concentrate of basic flotation	5.2	57.3	65.8	67.3	60.7
Concentrate of bioflotation	6.4	18.4	27.4	21.1	21.9
				88.4	
Tails	88.4	0.31	3.09	11.6	17.4
Initial raw material	100.0	4.6	9.0	100.0	100.0
6					
Concentrate of basic flotation	4.1	63.4	60.7	68.4	50.9
Concentrate of bioflotation	6.1	23.4	24.8	24.4	20.5
				92.8	
Tails	89.8	0.23	3.43	7.2	20.6
Initial raw material	100.0	4.6	9.0	100.0	100.0
7					
Concentrate of basic flotation	5.0	59.4	73.94	56.3	49.7
Concentrate of bioflotation	2.0	81.5	50.6	29.6	26.9
				85.9	
Tails	92.5	0.51	2.54	14.1	23.9
Initial raw material	100.0	4.6	9.0	100.0	100.0
8					
Concentrate of basic flotation	5.0	59.1	63.4	61.3	53.7
Cncentrate of bioflotation	2.1	42.8	28.3	12.1	24.6
				73.4	
Tails	92.3	0.61	2.96	26.6	21.7
Initial raw material	100.0	4,6	9.0	100.0	100.0

9					
Concentrate of basic flotation	4.5	31.7	61.3	61.4	71.3
Concentrate of bioflotation	4,4	46.8	67.4	22.1	10.4
				83.5	
Tails	90.1	0.41	3.7	16.5	18.3
Initial raw material	100.0	4.6	9.0	100.0	100.0
10					
Concentrate of basic flotation	5.6	66.7	98.4	54.7	50.9
Concentrate of bioflotation	1.8	89.3	63.5	27.7	23.9
				82.4	
Tails	92.6	0.31	4.2	17.6	25.2
Initial raw material	100.0	4,6	9.0	100.0	100.0
11					
Concentrate of basic flotation	5.5	49.4	71.3	51.4	57,3
Concentrate of bioflotation	2.0	27.3	31.4	21.4	31.4
				72.8	
Tails	92.5	0.62	3.8	18.2	11.3
Initial raw material	100.0	4.6	9.0	100.0	100.0
Comparative examples					
12					
Concentrate of basic flotation	6.2	34.0	62.0	45.8	42.7
Concentrate of bioflotation	7.1	11.2	27.2	18.2	22.6
				64.0	
Tails	84.3	2.16	3.40	36.5	31.8
Initial raw material	100.0	4.6	9.0	100.0	100.0

13					
Concentrate of basic flotation	8.2	23.7	50.0	42.2	45.6
Concentrate of bioflotation	7.5	11.2	27.2	18.2	22.6
				60.4	
Tails	84.3	2.6	3.40	39.6	31.8
Initial raw material	100.0	4.6	9.0	100.0	100.0
14					
Concentrate of basic flotation	5.2	64.6	98.4	54.7	50.9
Concentrate of bioflotation	2.2	53.6	81.3	19.8	23.6
				74.5	
Tails	92.6	9.46	4.2	25.5	26.5
Initial raw material	100.0	4.6	9.0	100.0	100.0
15					
Concentrate of basic flotation	6.1	31.2	64.1	41.4	43.4
Concentrate of bioflotation (2nd stage)	7.3	6.4	26.9	10.2	21.8
				51.6	
Tails	86.6	1.57	3.62	48.4	34.8
Initial raw material	100.0	4.6	9.0	100.0	100.0

As it is seen from the data of Table 1, the process for extracting gold from mineral suspension according to the invention allows to efficiently recover gold from the mineral suspension with the remaining gold in the bioflotation tails constituting between 0.19 to 0.61 grams per ton. Silver is also effectively extracted along with gold, and its residue in the bioflotation tails amounts to between 2.1 to 4.6 grams per ton (example 1 through 11)

At the same time, the implementation of the process under operation conditions beyond the claimed limits results in the reduction of the process efficiency. Thus, the increase in the amount of biomass to be introduced into the mineral suspension to the level lower to the

claimed limits causes the increase in the quantity of the remaining gold and silver in the bioflotation tails (example 12).

Similar effect is also produced by the increase beyond the claimed limits of the value of the intensity of electric field and of the extension of a period of its action upon the mineral suspension including the microorganism culture (example 13).

The rate of gold and silver extraction from the mineral suspension is negatively affected by the increase beyond the claimed limits of a period of action of the electric field upon the mixture of mineral suspension and microorganism culture in the process of agitation, even if the intensity of electric field is within the claimed limits (example 14)

High amount of gold and silver remains in the flotation tails in case when the agitation process as well as two-stage flotation is performed without the biomass of microorganism culture being added thereto (example 15).

The process of the invention for extracting gold from a mineral suspension may be used in the mining industry at plants for extracting gold present in the ore in a finely dispersed state.

It is quite obvious, that hereabove are given only some examples of practising the invention, and the other variants of realization of the invention may be possible within the limits to be defined by the claims.

CLAIMS:

1. A process for extracting gold from a mineral suspension consisting in that at least one stage of flotation is performed using a flotation reagent, characterized in that after at least one stage of flotation a biomass of microorganism culture in an amount between 10.0 to 30.0 grams per ton is introduced into the flotation tails, and agitation is carried out for a period between 6.0 to 10.0 minutes, following which a biomass of microorganism culture in an amount between 10.0 to 30.0 grams per ton is additionally introduced into the mixture of the flotation tails and microorganism culture, and the flotation of said mixture is performed for 12.0 to 15.0 minutes.

2. The process for extracting gold from a mineral suspension according to claim 1, characterized in that 0.5 to 1.0 minutes prior to the completion of agitation an electric field of intensity between 0.5 to 2.0 V/cm is created, and the agitation is performed under the effect of the electric field.

3. The process for extracting gold from a mineral suspension according to claim 1, characterized in that after the flotation of a mixture of the flotation tails and microorganism culture for between 2.0 to 3.0 minutes, an electric field of intensity between 1.5 to 2.5 V/cm is created, and the flotation of said mixture is carried out under the action of the electric field for a period between 1.0 to 1.5 minutes; the electric field is then switched off, and the flotation proceeds without the effect of the electric field.

4. The process for extracting gold from a mineral suspension according to claim 1, characterized in that 0.5 to 1.0 minutes prior to the completion of agitation, an electric field of intensity between 0.5 to 2.0 V/cm is produced, and the agitation is performed under the action of the electric field; after the flotation of a mixture of the flotation tails and microorganism culture for between 2.0

to 3.0 minutes an electric field of intensity between 1.5 to 2.5 is created, and the flotation of said mixture is carried out for a period between 1.0 to 1.5 minutes under the effect of the electric field, after which the electric field is switched off, and the flotation proceeds without the action of the electric field.

5. The process for extracting gold from a mineral suspension according to claim 1, characterized in that the **Bacillus cereus** B - 5039 is used as a microorganism culture.

6. A process according to claim 1 substantially as herein described with reference to any one of the illustrative Examples.

INTERNATIONAL SEARCH REPORT

Internat. Application No
PCT/GB 96/02538

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C22B11/08 C22B11/00 C22B3/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C22B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	WO 94 00608 A (BURNS COLIN JAMES) 6 January 1994 see figures 2-4; example 2 ---	2-5
A	GB 2 157 669 A (LINDE AG) 30 October 1985 see claims 1-10; example 2 --- -/--	1

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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Date of the actual completion of the international search	Date of mailing of the international search report
7 February 1997	21.02.97

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016	Bombeke, M

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INTERNATIONAL SEARCH REPORT

Internat Application No
PCT/GB 96/02538

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Interna l Application No
PCT/GB 96/02538

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